Building Algorithm Components for GPM Snowfall Retrieval

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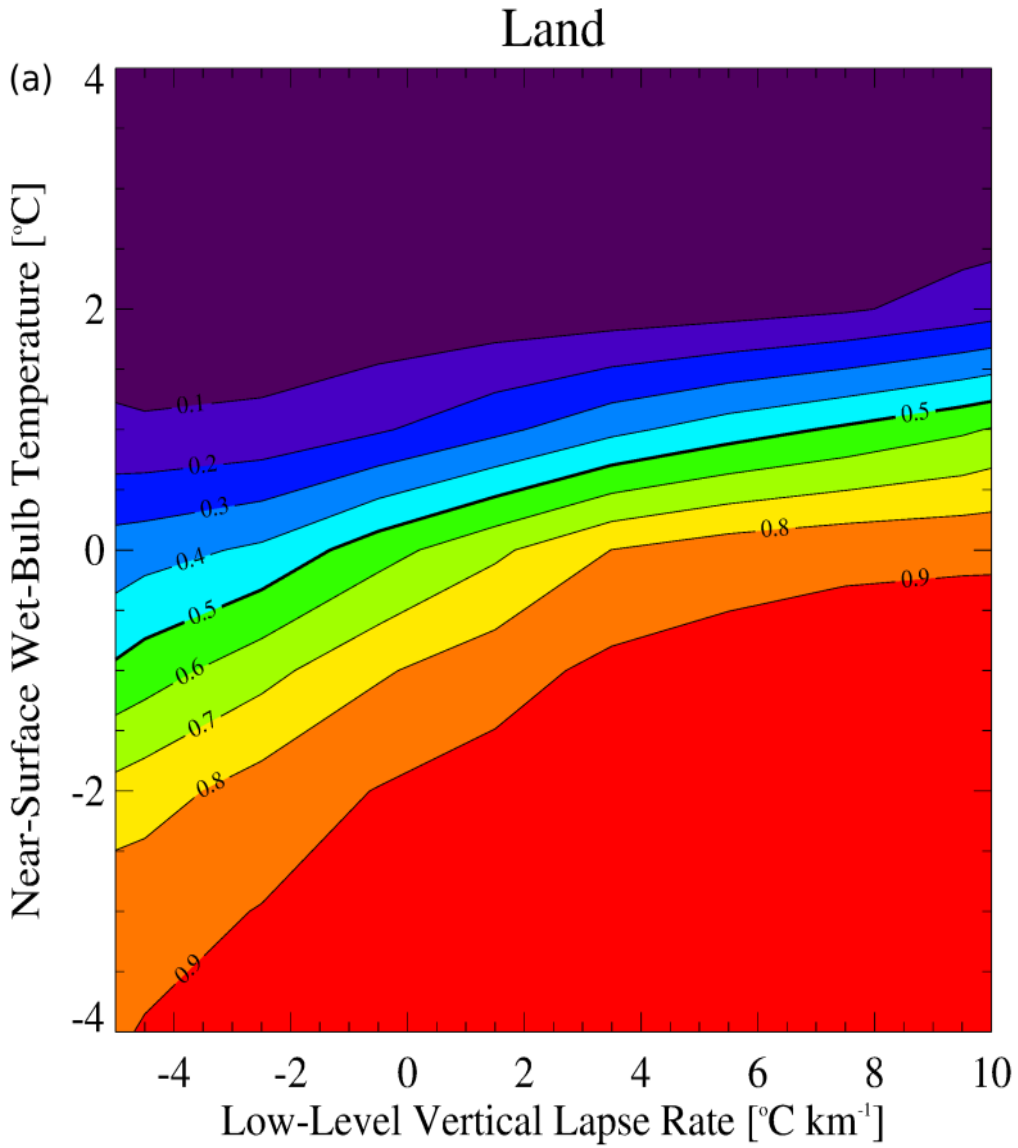
Contents

- Snow-Rain Separation using ancillary (non-satellite) data
- Sensitivity of MW channels to snowfall
- Snowfall detection/retrieval algorithm (primarily over land)
- Scattering database for nonspherical snowflakes
- Snow clouds – brightness temperature database (over ocean)

Snow-Rain Separation



Data Used:
Land: NCEP ADP Operational Global Surface Observations, 1997-2007
Ocean: International Comprehensive Ocean-Atmosphere Data Set (ICOADS), 1995-2007
Upper Air: Integrated Global Radiosonde Archive (IGRA)

Sensitive Variables

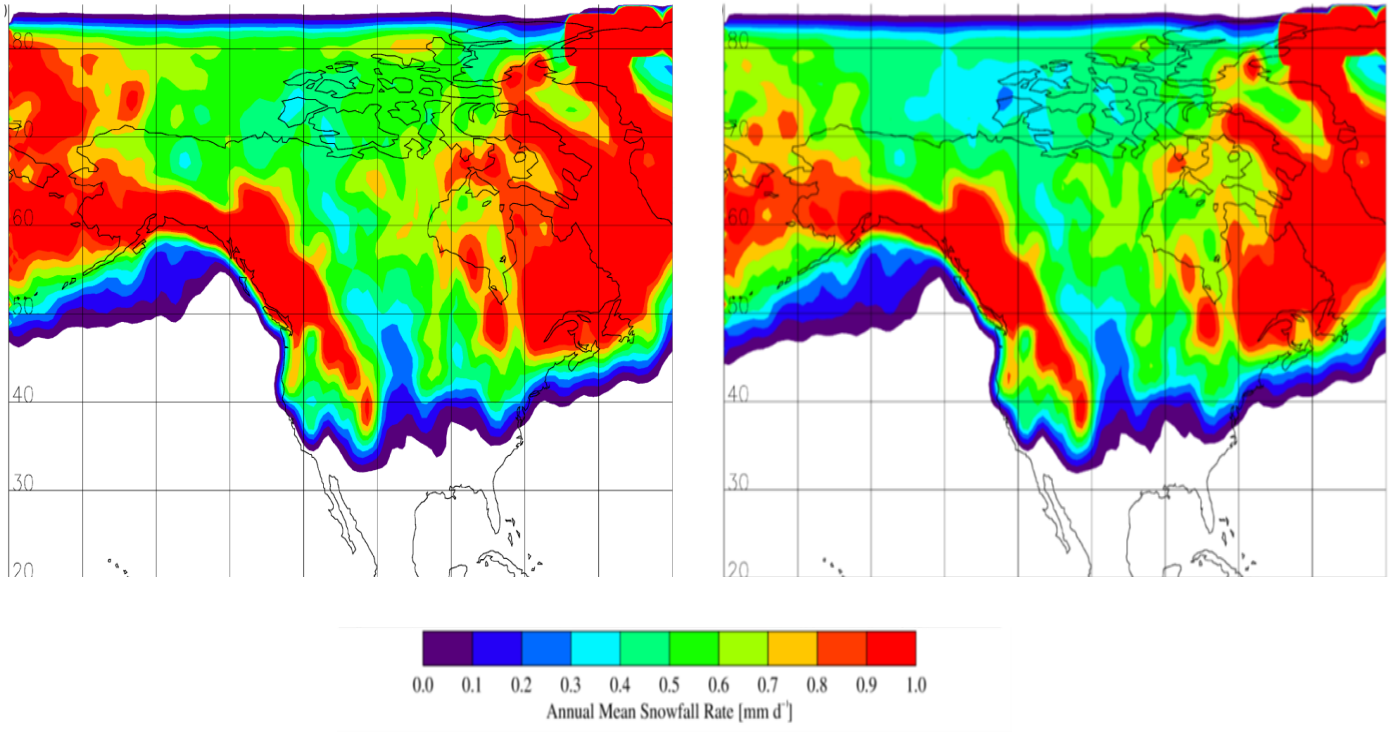
- **Air temperature (2 m)**
- **Humidity (2 m)**
- **Low-level (0 - 500 m) lapse rate**
- **Surface skin temperature**
- **Land or ocean**

Sims & Liu 2015 (JHM)

does it matter?

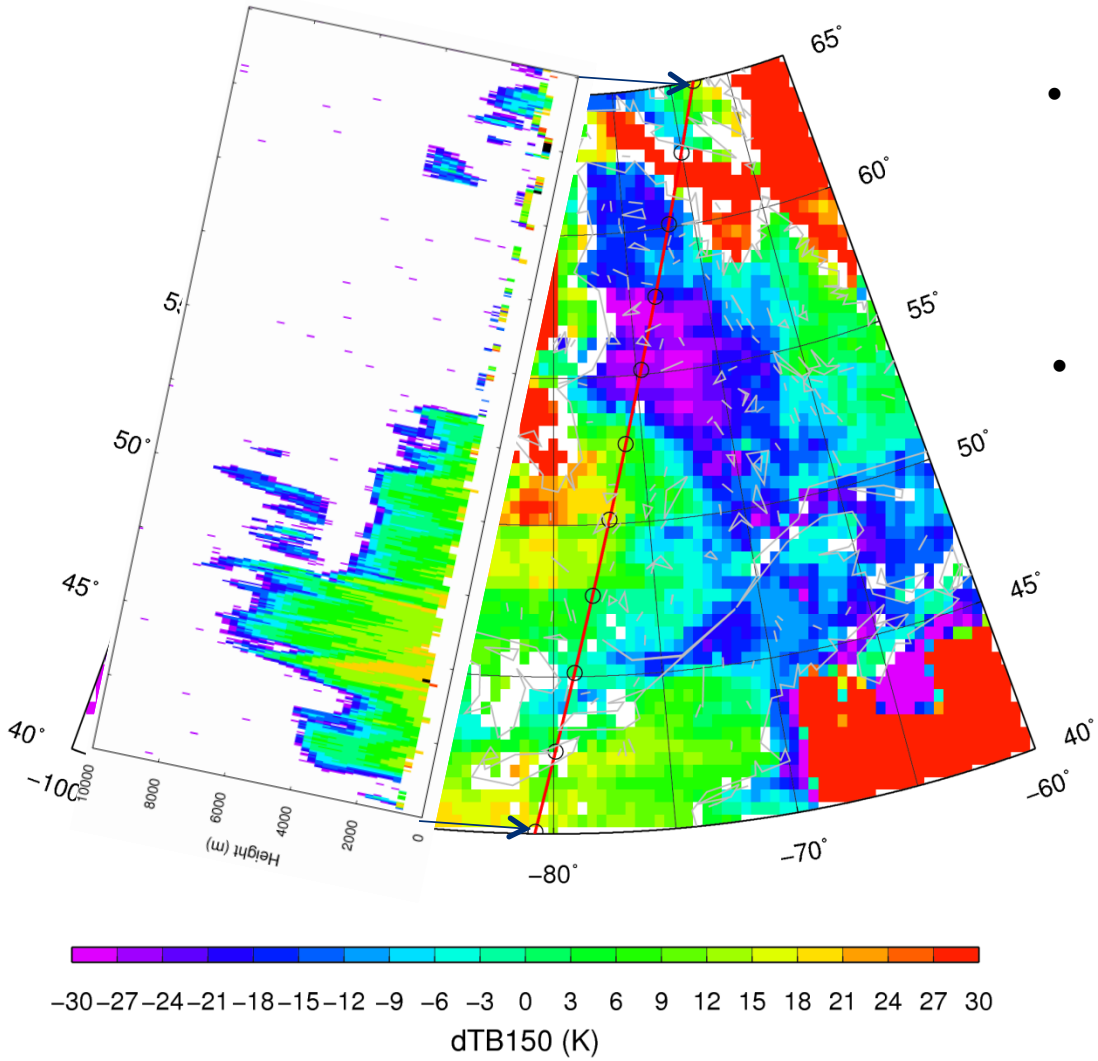
When using simple 2°C threshold

When using all-parameter threshold



Detection and Retrieval of Snowfall by Microwave radiometers

One of the problems in detecting snowfall by passive MW observations – supercooled liquid

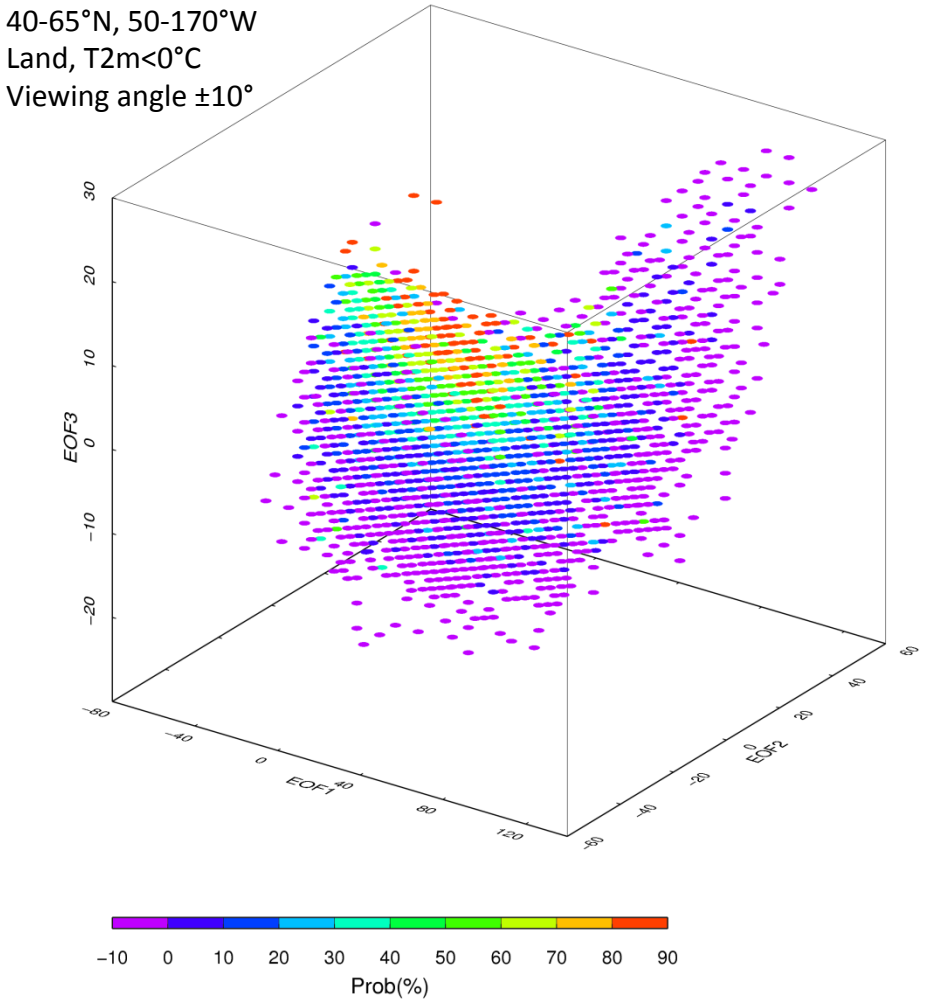


- The principle to detect snowfall from microwave obs. is to use TB decrease caused by ice-scattering
- Largest TB depression does NOT necessarily correspond to heavy snowfall
- Why ?

  Scattering by snowflakes competes with emission from cloud liquid.

Jan 22 2007 C3VP case w/CloudSat Over Pass ~ 0700UTC

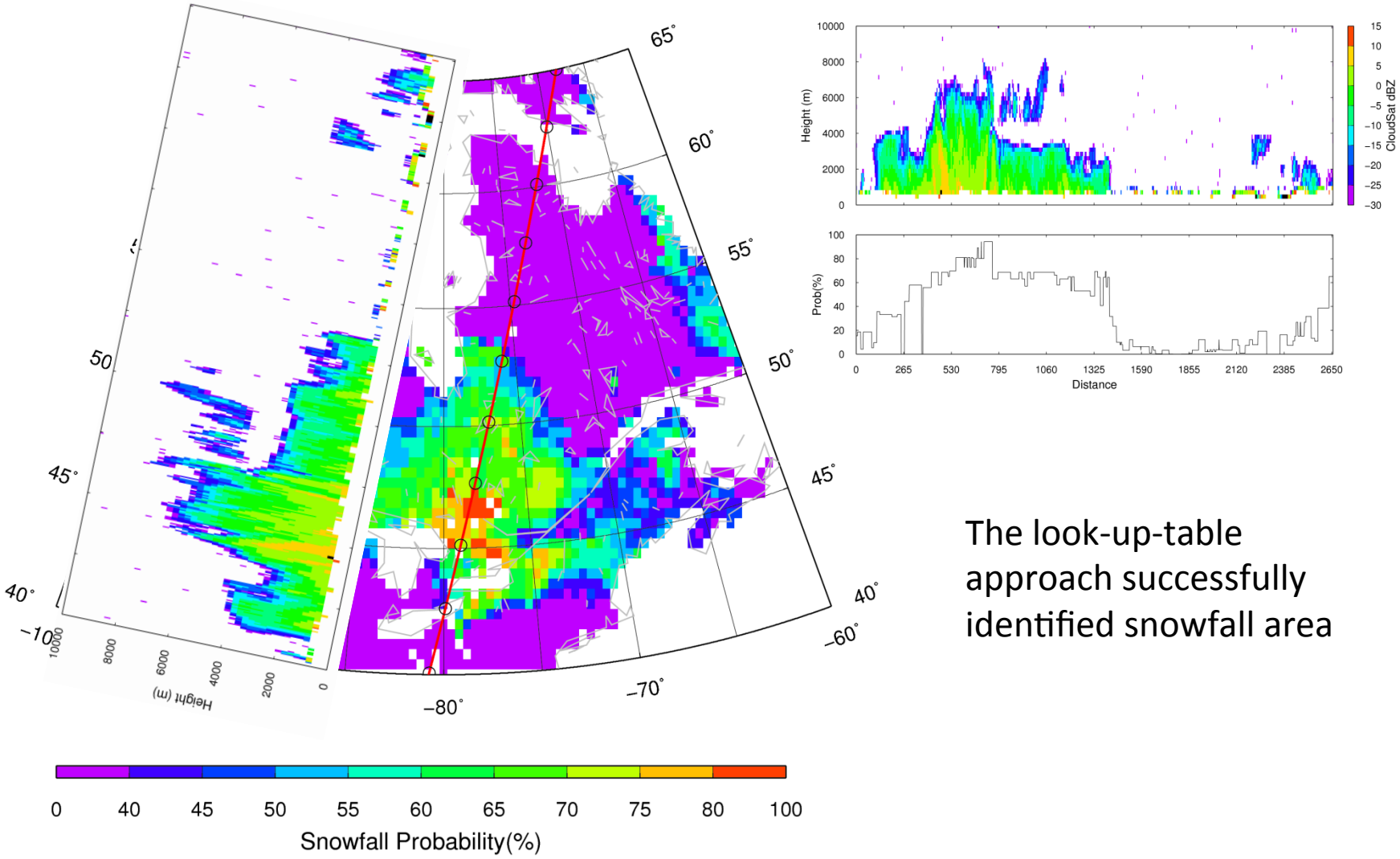
Radar-Trained Passive Microwave Snowfall Algorithm (CloudSat-MHS Matchups)



- EOF analysis to MHS data:
  - First 3 PCs – 88.6%, 8.2% and 2.1% of variances
  - PC3 had the best correlation Coeff to CloudSat reflectivity
- Lookup Table:
  - Project observed TBs to the first 3 PCs
  - In the 3-d EOF space, using MHS-CloudSat matchups, compute the probability of snowfall (CloudSat near-surface dBZe>-15)
  - Lookup tables for different MHS viewing angles
- Retrieve snowfall probability using the above lookup table; Use a Z-S relation, we can retrieve snowfall rate as well

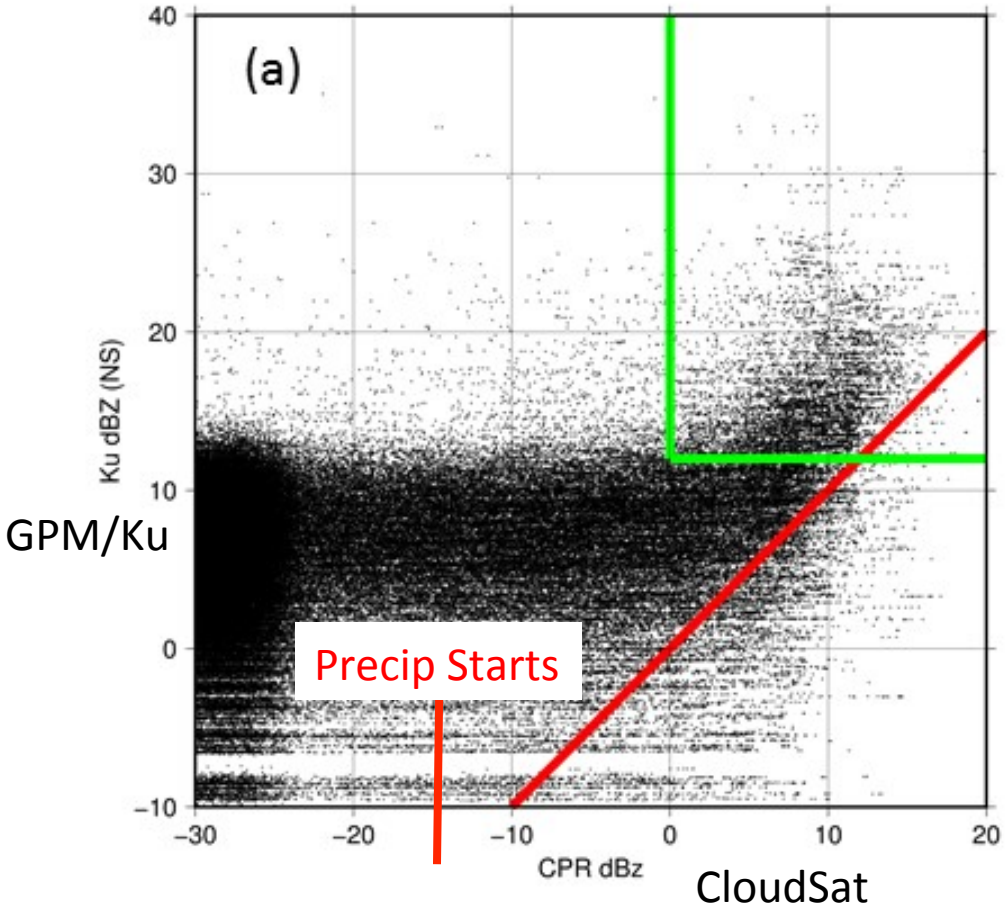
Liu&Seo, 2013

Apply to C3VP Case – 2007.1.22

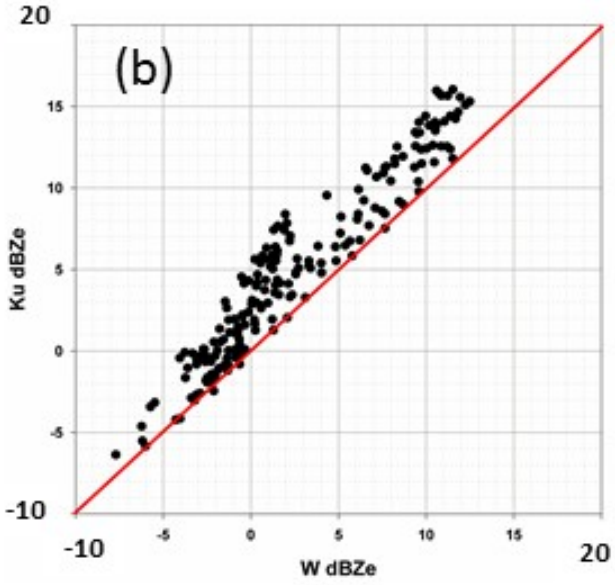


The look-up-table approach successfully identified snowfall area

Use combined GPM/DPR and CloudSat/CPR as “truth”

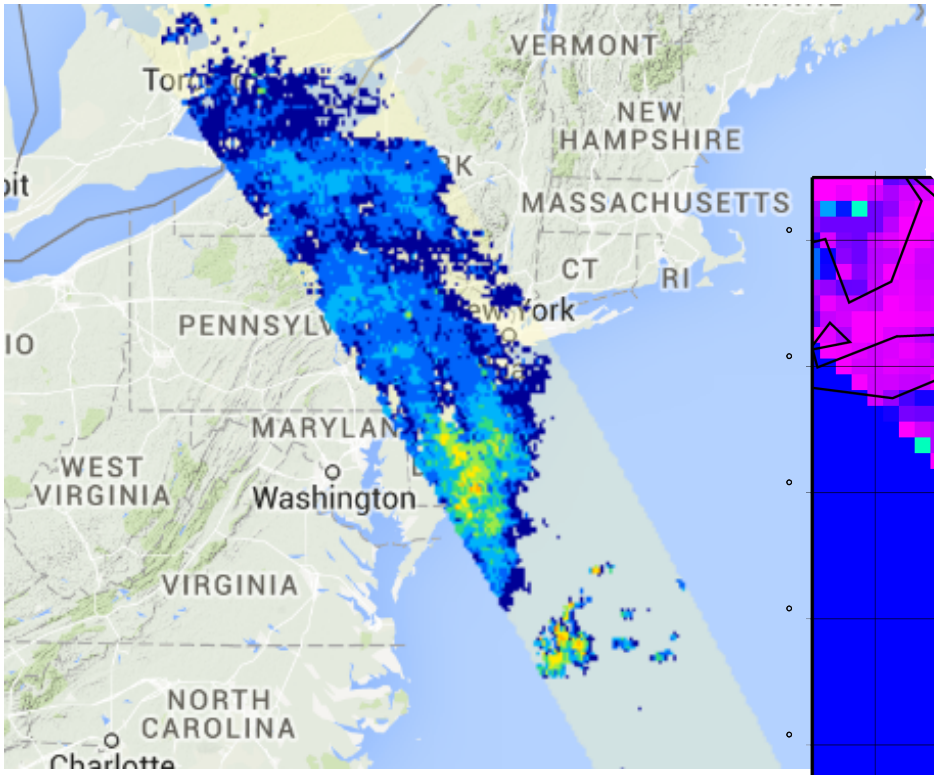


(a) Observed coincident CloudSat CPR vs. GPM DPR Ku dBZ and (b) computed W- vs Ku-band dBZ for sector snowflakes.



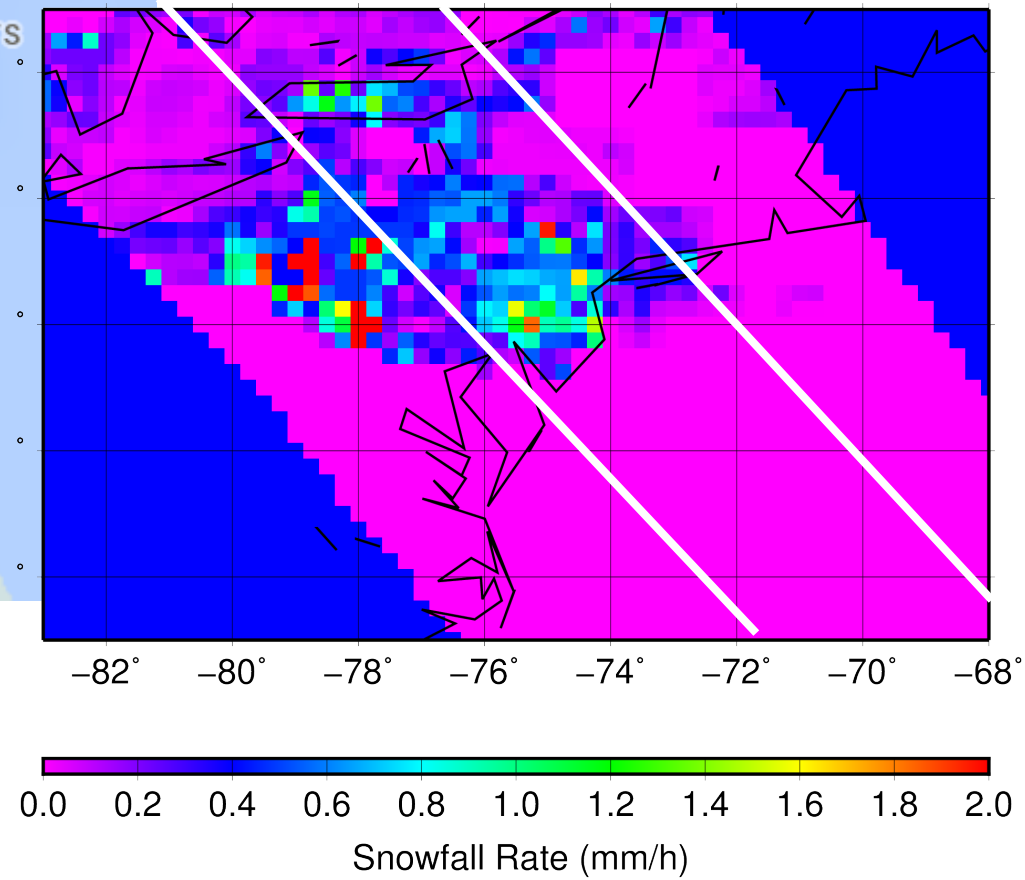
From 2BCSATGPM dataset of Turk (2015)

A Case on Feb. 2, 2015

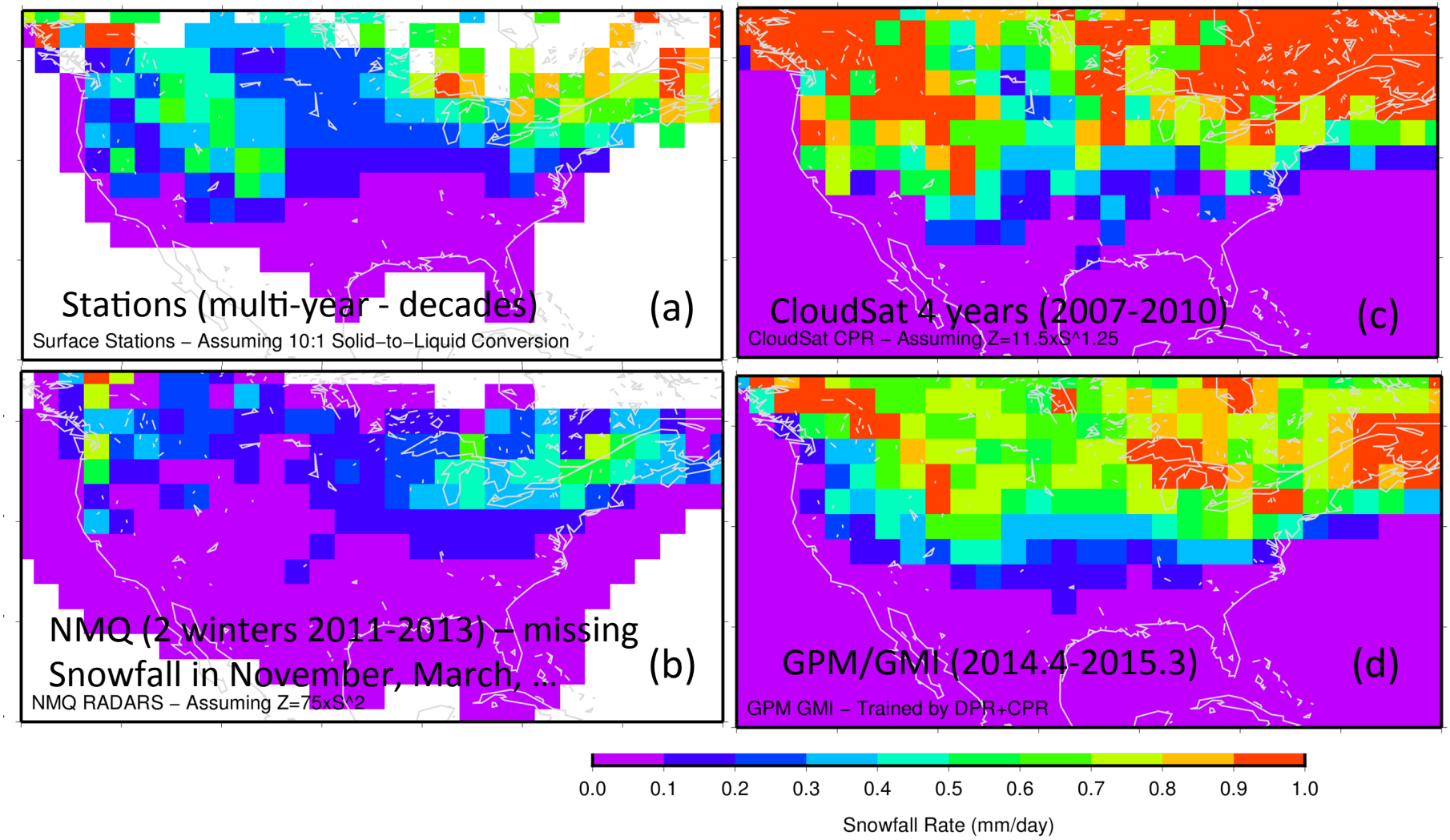


Ku “Rainfall”

GMI Snowfall



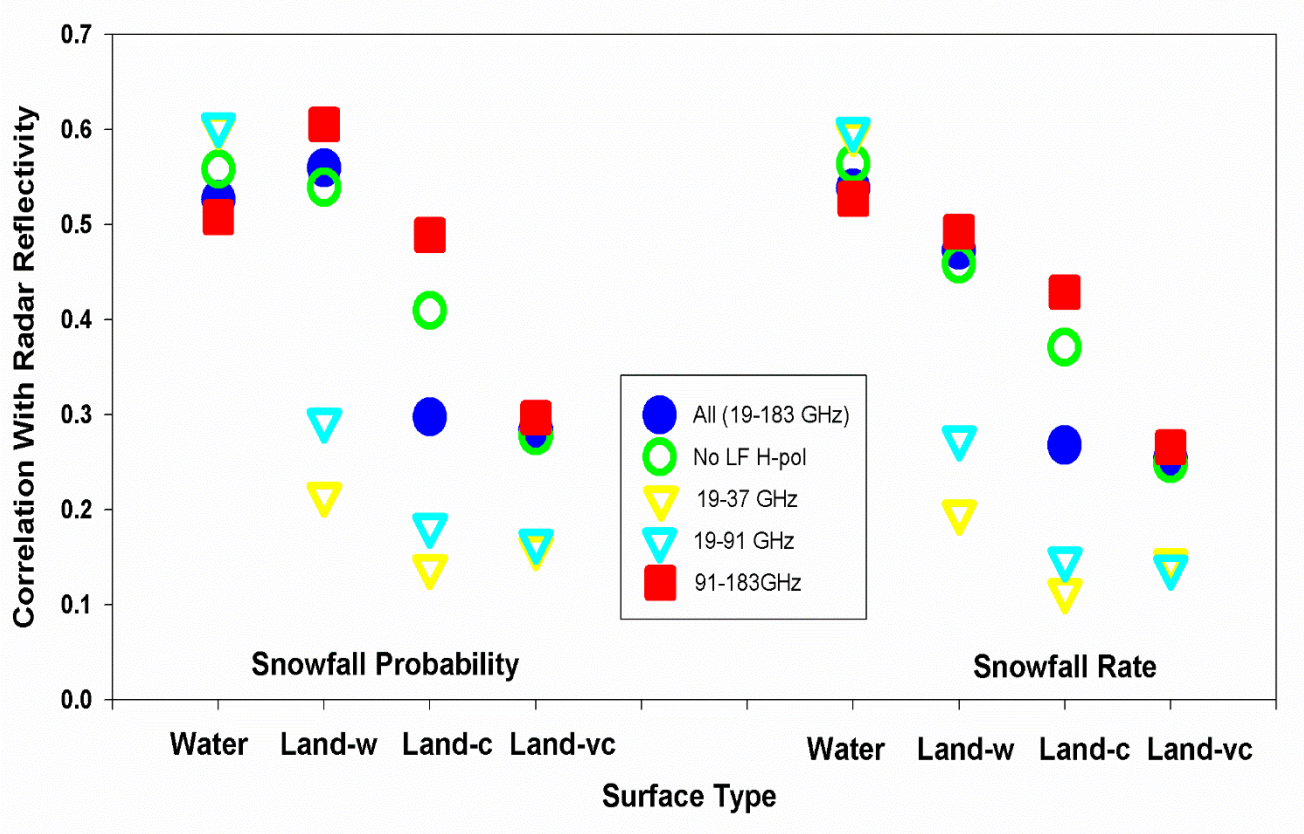
Annual mean snowfall over CONUS – compared to "climatology"



What are the best frequency-combinations for snowfall retrieval ?

- Collocate SSMIS and NMQ
  - SSMIS: 19, 22, 37, 50-60, 91, 150, 183±1,3,7 GHz
  - NMQ: U.S.+Canada Radar networks
  - MERRA: reanalysis
- Select cold-only (use a scheme separating between snowfall and rainfall) dataset, Create snow probability/snowfall lookup table
- Analyze the correlation between retrieved vs. observed snowfall probability and snowfall rate

Channel Selection for Snowfall Retrieval Based on Collocated SSMIS and NMQ Data



Insights gained:

1. High-freq (f>150 GHz) channels are essential for snowfall detection & retrieval;
2. 91-183 GHz only channels are as good as all 19-183 GHz channels;
3. Similar skills for detection (probability) and retrieval (snowfall rate)

Surf Type: 1.Water; 2.Land-w:Ts>-2°C; 3.Land-c: -8°C <Ts<-2 °C; 4.Land-vc: Ts<-8 °C

Use data from 6 winter months during 2011-2012 & 2012-2013

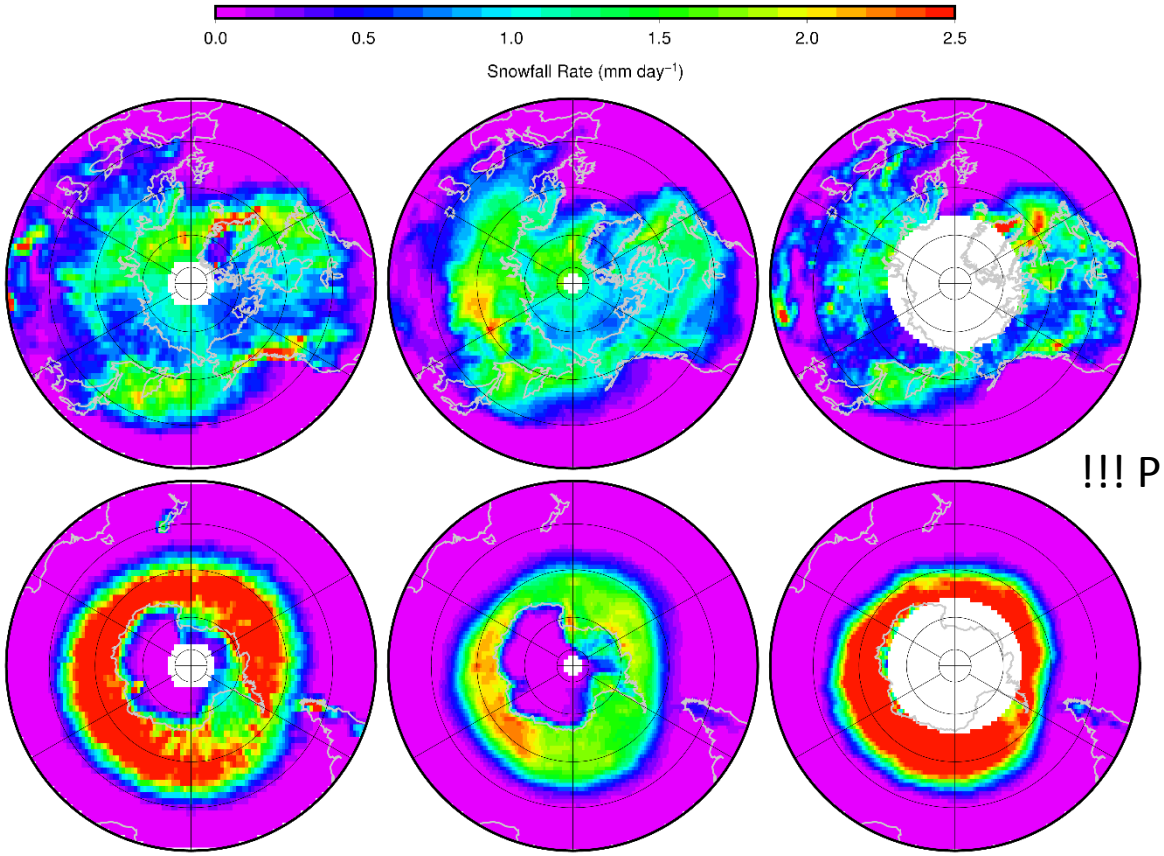
Large amount of satellite obs data

Satellite and sensors having high-frequency microwave observations
(U.S. and European Satellites only)

Satellite	*Sensor*	*Launch Date*
NOAA-15 (K)	AMSU-B	05/13/1998
NOAA-16 (L)	AMSU-B	09/21/2000
NOAA-17 (M)	AMSU-B	06/24/2002
NOAA-18 (N)	MHS	05/20/2005
NOAA-19 (N')	MHS	02/06/2009
EUMET-SAT MetOp-A	MHS	10/19/2006
MetOp-B	MHS	09/17/2012
DMSP F16	SSMIS	10/18/2003
DMSP F17	SSMIS	11/04/2006
DMSP F18	SSMIS	11/18/2009
DMSP F19	SSMIS	03/04/2014
S-NPP	ATMS	10/28/2011
GPM	GMI	02/27/2014

AMSU-B: Advanced Microwave Sounder Unit – B; MHS: Microwave Humidity Sounder; SSMIS: Special Sensor Microwave Imager Sounder; ATMS: Advanced Technology Microwave Sounder; GMI: Global Precipitation Mission Microwave Imager

Annual mean snowfall – global - compare 3 satellite retrievals



N. Hemisphere

S. Hemisphere

!!! Preliminary !!!

CloudSat CPR
4 years (2007-2010)

MHS & AMSU-B
4 years (2007-2010)

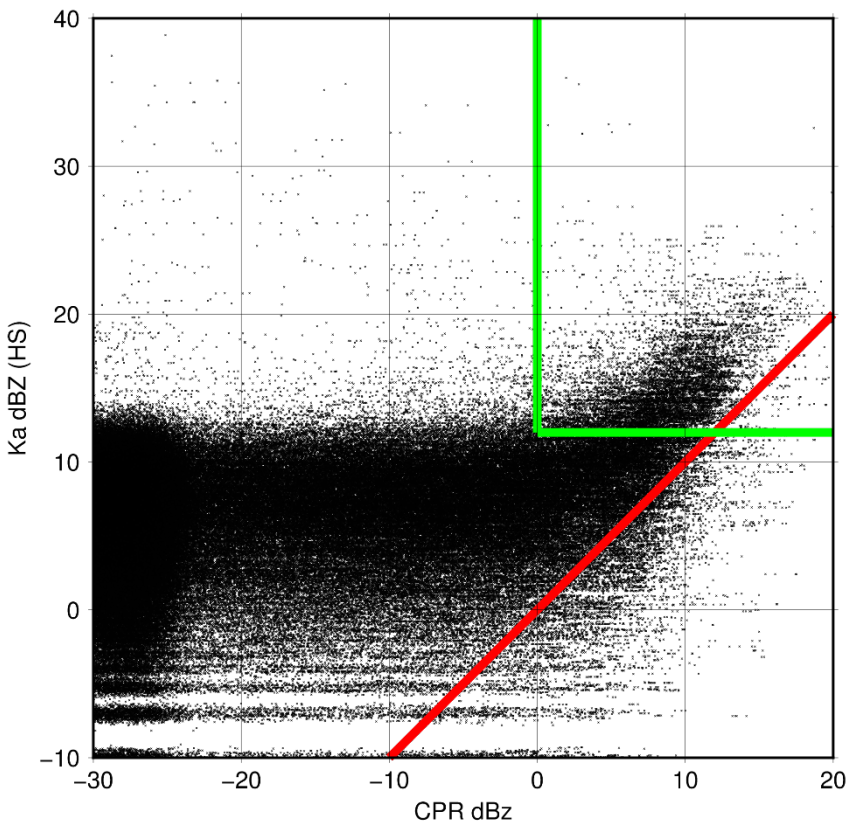
GPM GMI
1 year (2014.4-2015.5)

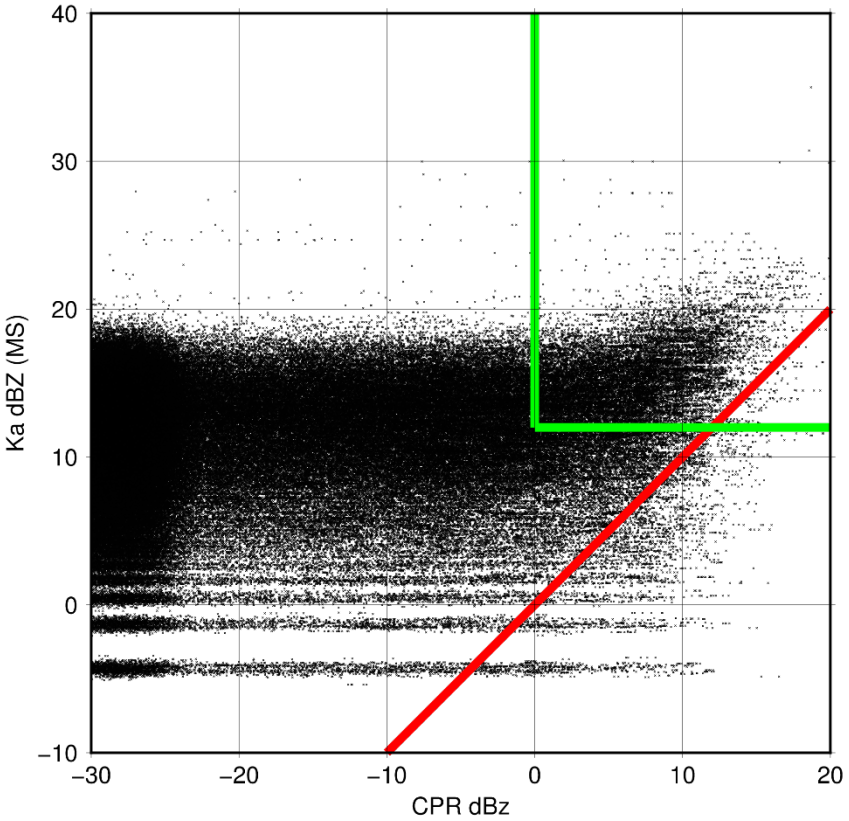
Conclusions

- Snow-rain separation algorithm – developed, need some refinement
- Scattering database – many types of particles including aggregate snowflakes, to include larger particles
- MW channels to snowfall – high-frequency (85 GHz and higher) channels necessary, and sufficient (?)
- Snowfall algorithm – empirical, developed based on GPM/DPR+CloudSat/CPR, produce reasonable snowfall "climatology" pattern, need to reconcile differences among several obs.

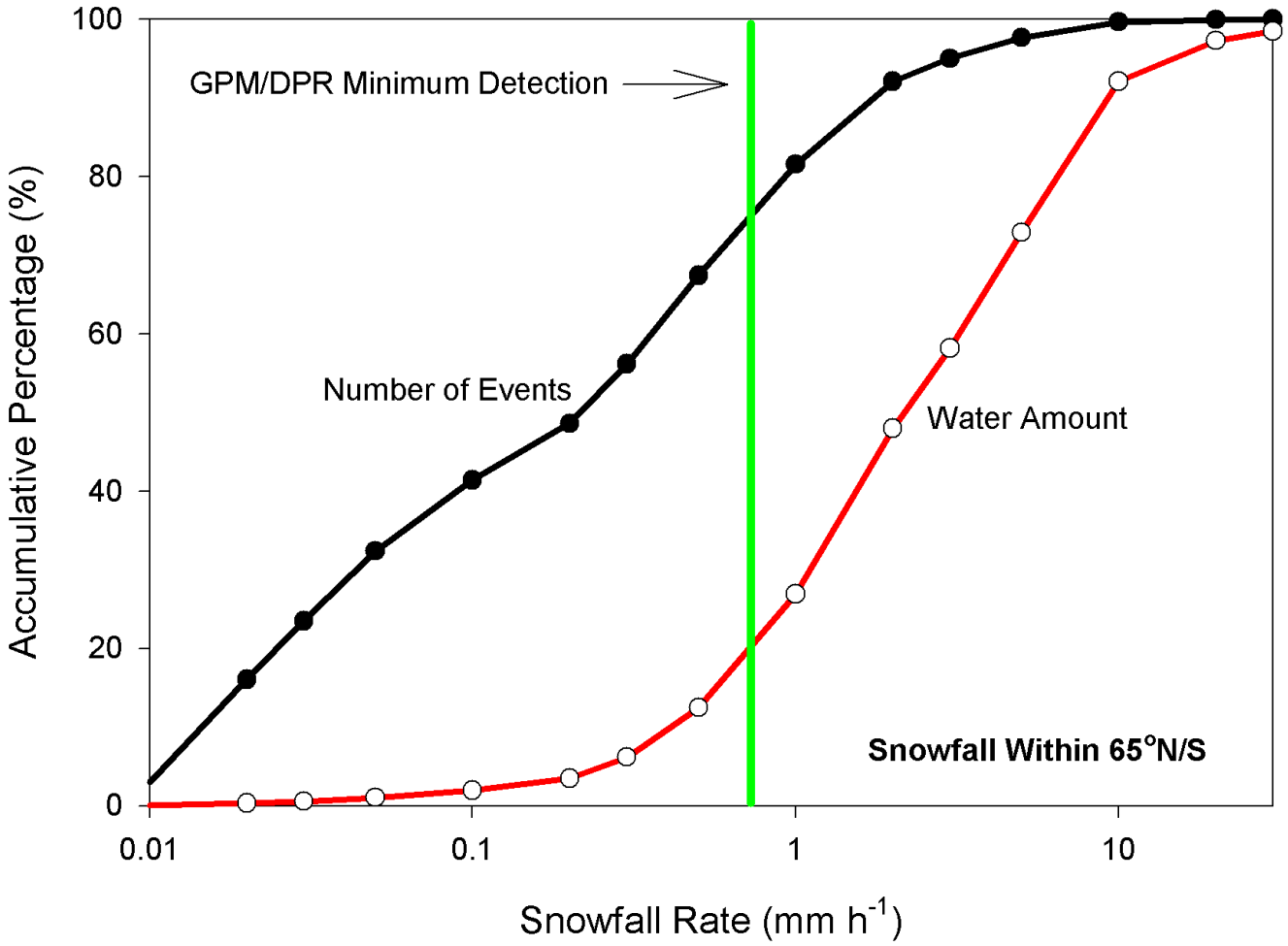
Backup Slides

Ka Sensitivity

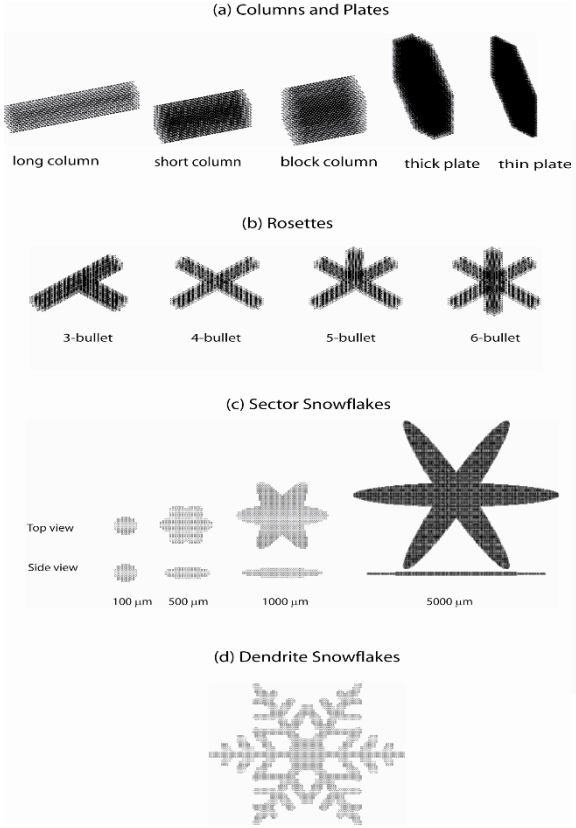




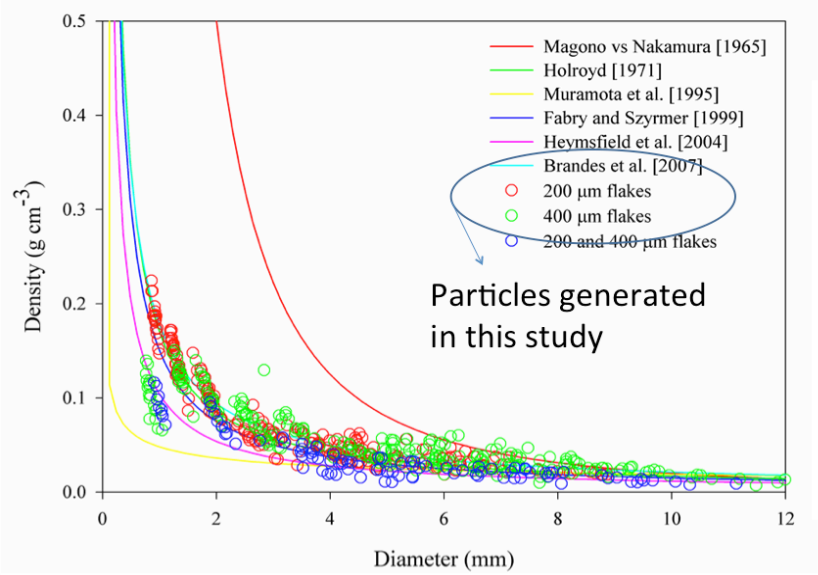
How much DPR misses for snow?

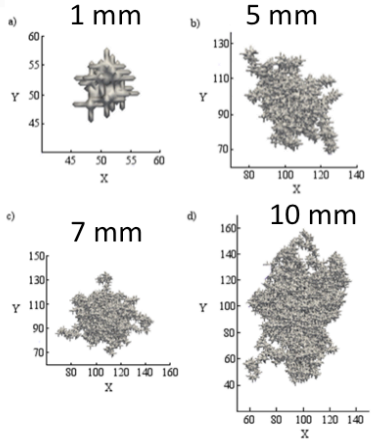


Scattering Database for Nonspherical Snowflakes



Crystal type particles (Liu, 2008)



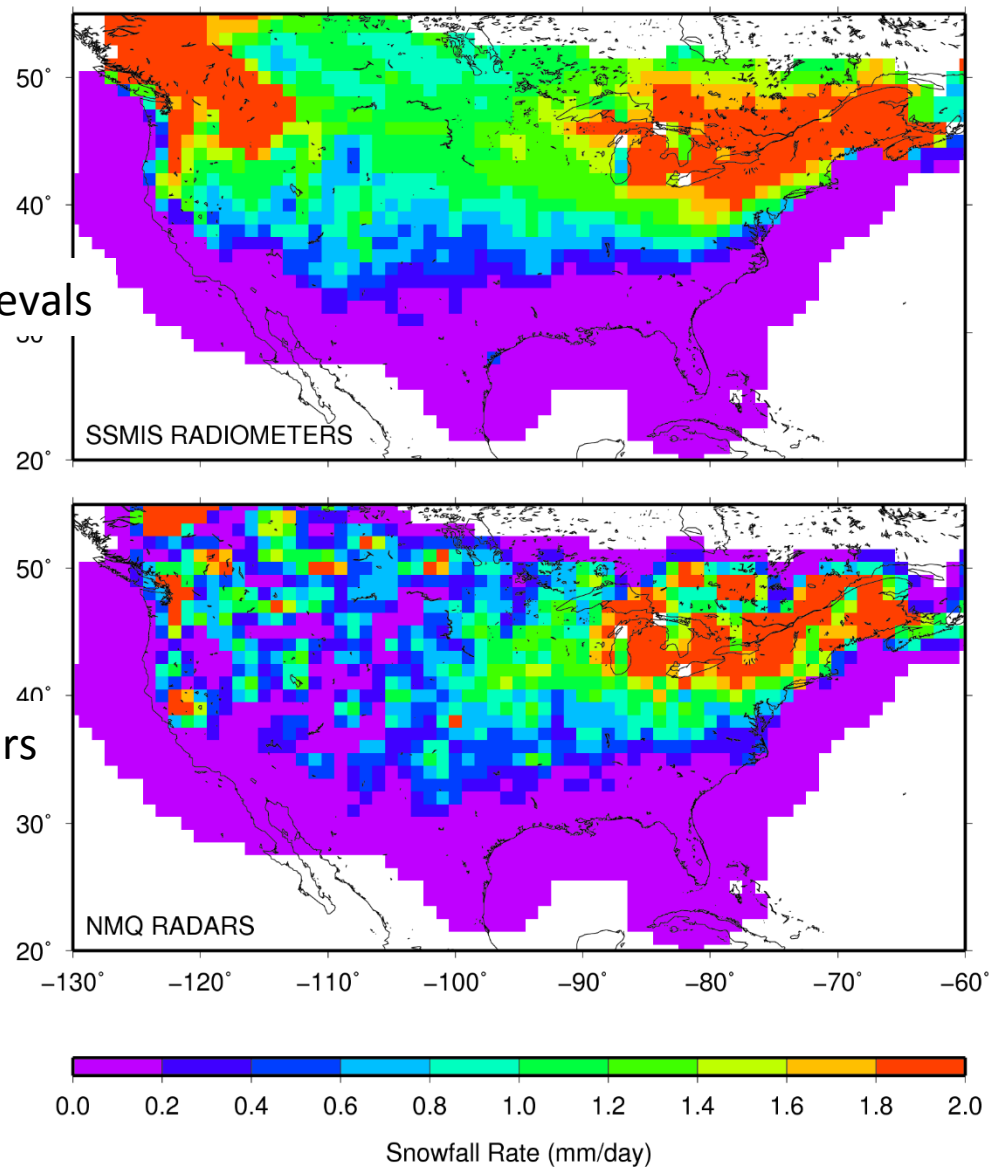


Aggregate snowflakes: rounded, oblate and prolate (Nowell, Liu and Honeyager, 2013; Nowell, 2015)

SSMIS Retrievals vs NMQ
- Use 91-183 GHz Channels

Satellite Retrievals

Surface Radars



Average of 6 winter months:
2011-2012 & 2012-2013

Look-up-table:
Calibrated by NMQ
(2011-2013)